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**Feasibility Study Report
Terminal 1 South
Portland, Oregon**



**Prepared for
Port of Portland
Project/Task No. 24232/760**

**March 25, 2002
15230**

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**Feasibility Study Report
Terminal 1 South
Portland, Oregon**

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**Prepared for
Port of Portland
Project/Task No. 24232/760**

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15230**

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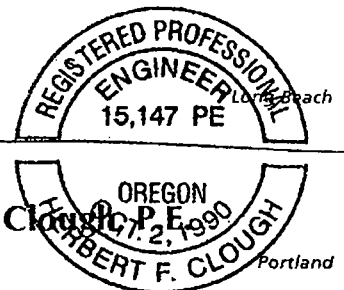
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EXPIRES: DEC. 31, 2003

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FEASIBILITY STUDY REPORT TERMINAL 1 SOUTH PORTLAND, OREGON

EXECUTIVE SUMMARY

This document describes the feasibility study (FS) for the Port of Portland at the Terminal 1 South Site (T1S Site) in Portland, Oregon. The FS discusses alternative remedies that are available to reduce to an acceptable level existing and potential future risks to human health and the environment associated with petroleum hydrocarbon and metal contamination at the site. The risks were evaluated in the Human Health and Ecological Baseline Risk Assessment Report (Hart Crowser, 2002a).

The project site, T1S Site, is located at 2100 NW Front Avenue in Portland, Oregon (Figure 1). The site consists of approximately 21 acres that are almost completely paved with asphalt or concrete or covered by buildings (Figure 2). Two primary structures, designated as Warehouse No. 2 and House No. 104, are currently located at the T1S Site. An extensive dock structure is present over submerged lands at Berths 104, 105, and 106. Historically, Terminal 1 has been used for staging of lumber, logs, paper products, steel containers, and bagged grain. The T1S Site will be redeveloped for residential and commercial purposes.

Environmental investigations and risk assessment conducted at the site identified T1S Site soils exceeding acceptable risk levels. Likely or potential sources of contamination include underground storage tanks and dry wells. Polynuclear aromatic hydrocarbons (PAHs), arsenic, and lead are the contaminants of concern at the site.

The remedial action objective is to prevent human contact or ingestion of soil impacted by PAHs, lead, and arsenic above defined cleanup levels. To ensure the remedial action objective is met, each remedial action alternative was evaluated to assess its protectiveness based on the standards in OAR 340-122-040, and the balancing factors outlined in OAR 340-122-093 (3) and (4).

Remedial technologies associated with a list of general response actions were screened for effectiveness and applicability based on land use and site conditions. These technologies were also combined as necessary to form viable remediation alternatives (several technologies, such as monitoring, were included in all alternatives). The combined alternatives were evaluated for protectiveness, against the balancing factors (effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost), and the degree to which they address hot spots. The alternatives were then compared against one another to identify the alternative that overall best meets the selection criteria.

Based on the following, we recommend the implementation of either the landfill or thermal treatment alternatives. These alternatives are protective of public health, safety, and welfare and of the environment by preventing exposure of receptors to the contaminants. These alternatives address hot spots by removal to an off-site landfill or treatment by thermal desorption.

1.0 INTRODUCTION

This document describes the feasibility study (FS) for the Port of Portland Terminal 1 South (T1S Site) in Portland, Oregon. The FS discusses alternative remedies that are available to reduce existing and potential future risks to human health and the environment associated with petroleum hydrocarbon and metal contamination at the Site. The FS was prepared in accordance with Oregon Administrative Rules (OAR) for remedy selection (OAR 340-122-090) and the Department of Environmental Quality (DEQ) guidance (1998).

1.1 Purpose and Scope

The purpose and scope of the activities associated with this report were detailed in the Feasibility Study Scoping Document (Hart Crowser, 2002b) prepared for the Site. The Feasibility Study Scoping Document described the activities to be conducted in the evaluation of the remedial alternatives for the Site. The FS is based on the information collected from the Remedial Investigation Report - Volumes 1 and 2 (Hahn and Associates, 2001a) and the Monitoring Well Installation and Groundwater Sampling Report (Hahn and Associates, 2001b). The primary objectives of the FS were to identify a range of remedial options appropriate for the T1S Site and develop the information necessary to select an appropriate remedial action alternative that meets the standards listed in OAR 340-122-040 and OAR 340-122-090.

During the FS development, a comprehensive and rational process was used for screening a broad spectrum of remedial options to address the risks identified during the risk assessment. Major tasks associated with the FS include:

- Developing remedial action objectives;
- Screening remedial technologies;
- Developing and screening remedial action alternatives;
- Completing a detailed evaluation of protective and feasible alternatives; and
- Recommending a remedial action alternative.

1.2 Report Organization

The following is a brief overview of the organization of the report.

Site Location, Description, and History. The main body of this report begins with Section 2.0, which includes a discussion of the Site location, description, and brief history of documented releases to the environment. We then present an overview of the investigations conducted to date documented in the remedial investigation (RI) reports. This section also summarizes the results from the risk assessment and concludes with an evaluation of the potential for hot spots.

Remedial Action Objectives. Section 3.0 of this report defines and discusses the goals of future remedial actions at the Site and develops appropriate remedial action objectives to meet these goals. Other topics addressed in this section include determination of quantities (i.e., area and volume) for the media of concern and a discussion of the criteria used in evaluating remedial action alternatives.

Technology Evaluation and Remedial Action Alternatives. Upon establishing remedial action objectives, a list of general response actions are developed and presented in Section 4.0 to address the Site conditions identified in the RI reports. These general response actions form the basis for generating and screening technologies. Potential remedial technologies were developed for each general response action identified. Technologies were then evaluated with respect to specific Site conditions, waste characteristics, and the ability to achieve the remedial action objectives. The technologies remaining after the screening process can then be combined to create potential alternatives for further detailed analysis.

Detailed Analysis of Remediation Alternatives. The potentially feasible remedial action alternatives are more fully developed in Section 5.0 of the FS. The protective alternatives are evaluated on the basis of the balancing factors: effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost. Alternatives are also evaluated on the basis to which they address hot spots. The evaluation includes sufficient detail to identify comparative or relative differences among alternatives.

Comparative Evaluation of Remedial Action Alternatives and Recommendations. After completion of the detailed screening, the feasible Site alternatives are then ranked (Section 6.0). Within each balancing factor, the alternatives are compared to all others to generate an overall ranking. Based on the results of the comparison rankings, a remedial action alternative is recommended. The recommended remedial action alternative is discussed in Section 7.0.

1.3 Limitations

All work performed by Hart Crowser was completed in accordance with generally accepted professional practices related to the nature of the work accomplished, in the same or similar localities, at the time the services were performed. This report is for the specific application to the referenced project and for the exclusive use of the Port of Portland. No other warranty, express or implied, is made.

2.0 SITE LOCATION, DESCRIPTION, AND HISTORY

This section summarizes the available information on this site. A more detailed description of environmental activities and the results of the RI conducted at this site are provided in the Terminal 1 South Remedial Investigation Report (Volumes 1 and 2) prepared by Hahn and Associates (Hahn and Associates, 2001a) and the Monitoring Well Installation and Groundwater Sampling Report (Hahn and Associates, 2001b).

2.1 Site Location and Description

2.1.1 Site Location

The T1S Site is located at 2100 NW Front Avenue along the Willamette River in Portland, Oregon (Figure 1). The site consists of approximately 21 acres located northwest of Interstate 405 (Fremont Bridge), northeast of NW Front Avenue, southeast of Slip No. 2, and southwest of the Willamette River (Figures 1 and 2). For the purpose of this FS, the T1S Site does not include sediments adjacent to the Site.

2.1.2 Site Description

Two primary structures, designated as Warehouse No. 2 and House No. 104, are currently located at the T1S Site. Tristar Transload currently leases and operates the open storage area between Slip No. 2 and House No. 104 and portions of House No. 104. The remaining portions of the site are unoccupied. Additionally, an extensive dock structure is present adjacent to the T1S Site over submerged land at Berths 104, 105, and 106.

The topography at the T1S Site is generally level at an elevation of approximately 30 feet above mean sea level (msl). The site is generally paved with asphalt or concrete with no vegetation and little bare ground present.

2.1.3 Site History

The site history presented here is summarized from information contained in a Preliminary Assessment (PA) (Port of Portland, 2000) prepared for the T1S Site. In approximately 1884, upland areas in the vicinity of Terminal 1 extended 100 to 200 feet northeast of Front Avenue. By 1908, they extended approximately 200 to 400 feet northeast of NW Front Avenue. Since that time, various portions of the T1S Site have been filled and dredged. Slip Nos. 1 and 2 were created by dredging in approximately 1914 and 1923, respectively. Filling activities at the site were generally completed in approximately 1972 when Slip No. 1 was filled.

Between 1913 and 1936, the Commission of Public Docks (CPD) purchased various parcels of property in four primary phases. Three of these parcels now make up the Marine Terminal 1 South complex. The CPD merged with the Port on January 1, 1971.

Prior to and during World War II, Terminal 1 and the adjacent industrial neighborhood supported expanded activities on behalf of the war effort. Ship building and repair at the Willamette Iron and Steel Corporation facility formerly located at Terminal 1 necessitated increased dock front dredging (for larger ship berths) and the occasional use of Terminal 1 property for temporary equipment storage.

In 1946, the CPD purchased the Eastern and Western Lumber Company property to the immediate north of Terminal 1 South. The Willamette Iron and Steel Corporation, now adjacent to the CPD terminal, changed ownership in the same year, becoming the Willamette Iron and Steel Company.

Historically, Terminal 1 has been used for the staging of lumber, logs, paper products, steel containers, and bagged grain. Various companies have owned or leased portions of the Terminal 1 South Complex (see RI Report; Hahn and Associates, 2001a). It is anticipated the T1S Site will be redeveloped for residential and commercial purposes.

2.2 Previous Site Investigations

In July 2001, Hahn and Associates completed an RI at the T1S Site (Hahn and Associates, 2001a). RI activities completed at this site consisted of the following six phases:

- Focused Environmental Site Assessment completed by Maul Foster in 1998 (Maul Foster & Alongi, 1998);
- Environmental Baseline Investigation completed by Hahn and Associates in February and March 2000 (Hahn and Associates 2001a);
- B-38 Area Characterization completed by Hahn and Associates in March 2000 (Hahn and Associates 2001a);
- Supplemental Site Characterization Activities completed by Hahn and Associates in September 2000 (Hahn and Associates 2001a);
- Data Gap Investigation completed by Hahn and Associates during October and November 2000 (Hahn and Associates 2001a); and
- Groundwater Investigation completed by Hahn and Associates during August, September, and October 2001, and January 2002 (Hahn and Associates, 2001b and 2002).

A total of 112 push probe borings were installed for the collection of soil and groundwater samples during these site activities. The locations of these push probe borings are presented on Figure 2. Please refer to the RI Report (Hahn and Associates, 2001a) for further discussion of these activities and results.

The groundwater investigation included installation, development, and sampling of seven groundwater monitoring wells at the site. The locations of the groundwater monitoring wells are presented on Figure 2. Please refer to the groundwater sampling report for further discussion of these activities and results (Hahn and Associates, 2001b).

2.3 Remedial Investigation Summary

These activities provided a detailed understanding of the site and surrounding vicinity.

2.3.1 Geology and Hydrogeology

- The subsurface soils encountered during the investigations were predominantly sands and silts with occasional gravel to the maximum depth of investigation at 80 feet below ground surface (bgs).
- Based on historical documentation and investigations, the property has been extensively filled-in over time; fill material was encountered at all push probe locations from the surface to depths of 32 to 67 feet bgs.
- Soils thought to be former Willamette River sediments were encountered at the former Slip No. 1 (B-84) at a depth of approximately 67 feet bgs.

- Soils encountered beneath NW Front Avenue were generally siltier than those encountered on the T1S Site, suggesting the soils in the right of way are either alluvial in origin or are from a different fill source than that of the site.
- Groundwater in the vicinity of the T1S Site generally occurs in three principal hydrogeologic zones: (1) a shallow unconfined fill/alluvial deposit (shallow water-bearing zone [WBZ]); (2) generally confined Troutdale WBZ; and (3) the confined Columbia River Basalt WBZ.
- Unconfined groundwater was encountered within the shallow WBZ (fill) at an average depth of approximately 23 feet bgs.
- Groundwater elevations measured in the seven monitoring wells installed at the T1S Site on September 28 and October 30, 2001, indicate a general flow to the northeast towards the Willamette River with a decline or even reversal of the gradient near the river (Hahn and Associates, 2001b).

2.3.2 Land and Water Use

The locality of the facility (LOF) is defined as "any point where a human or ecological receptor contacts, or is reasonably likely to come into contact with, facility related hazardous substances."

Chemicals have been detected in both soil and groundwater at various areas of the site, but off-site migration of contamination is not evident based on the existing data. Accordingly, the LOF is defined only as the T1S Site and the adjacent area on Front Avenue in Area A (Hahn and Associates, 2001b).

Historical Land Use. The approximate 21-acre T1S Site has historically been zoned as "IH" for Heavy Industrial. Surrounding adjacent properties are zoned "IH" Heavy Industrial and "EX" Central Employment.

Current and Reasonably Likely Future Land Use. The current and reasonably likely future land use in the LOF is well defined. The site is currently zoned as Central Residential (RX) such that it can be redeveloped for an alternative use. The RX zoning is considered the comprehensive plan for the property. Based on the RX zoning designation, it is expected the site will be used for mixed-use residential/commercial development in the future.

A beneficial groundwater use evaluation was conducted for the Hoyt Street Property (RETEC, 1997) that adjoins the southeast corner of the T1S Site. Hahn and Associates conducted an additional well inventory as part of the RI and the groundwater monitoring study to supplement the RETEC survey. Based on trends in groundwater use in the area and RETEC fate and transport modeling,

the only identified beneficial use for groundwater in the LOF is discharge to the Willamette River. No water wells were found to be in use within 0.5 mile of the T1S Site. No surface water rights were identified within 0.5 mile of the T1S Site.

2.4 Risk Assessment Results

Hart Crowser conducted a human health risk assessment (HHRA) and a Level 1 Scoping and Modified Level 2 Screening ecological risk assessment (ERA) for the T1S Site (Hart Crowser, 2002a). Potentially exposed populations that were evaluated in the HHRA include future residents, current and future commercial workers, and future utility/excavation workers. The T1S Site is being redeveloped for residential and commercial purposes. The site will be developed into three areas (A, B, and C), which were evaluated as separate areas of concern (AOCs). Separate COPCs were identified and separate risk calculations were conducted for each AOC. The AOCs are presented on Figure 2. Risk and hazard estimates were evaluated for each area (A, B, or C) and are described below.

Human Health Risk Assessment Results for Area A. The exposure pathways that were quantitatively evaluated at Area A were soil ingestion, dermal contact with soil, inhalation of volatiles from groundwater, and inhalation of fugitive dust.

The assessment of carcinogenic risks to residential receptors at Area A indicated that under both Reasonable Maximum Exposure (RME) and Central Tendency (CT) conditions, the potential risks exceeded DEQ acceptable risk levels. Compounds of Potential Concern (COPCs) that exceeded the DEQ acceptable risk level for individual carcinogens are benzo(a)pyrene, benzo(a)anthracene, dibenz(a,h)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and arsenic. The assessment of noncarcinogenic risks identified only lead as present above acceptable risk levels for residential exposure under both RME and CT conditions.

For the commercial worker exposure scenario, the estimated cumulative carcinogenic risks were found to be acceptable under both RME and CT conditions. However, benzo(a)pyrene and arsenic exceeded the DEQ acceptable risk level for individual carcinogens. The assessment of noncarcinogenic risks identified lead as present above the acceptable risk level for the commercial worker exposure under only the RME condition.

For the excavation worker exposure scenario, no unacceptable risks from exposure to carcinogens were identified. The assessment of noncarcinogenic risks identified lead as present above the acceptable risk level for the excavation worker exposure under only the RME condition. The excavation worker is the only applicable exposure pathway for Naito Parkway. No acceptable risks were identified for the excavation worker for contamination detected beneath the roadway.

The RME and CT exposure point concentrations (EPCs) for lead in surface and total soil in Area A are driven by the maximum detection in one sample (B-68). If the soil associated with the sample were removed, the lead EPCs would be acceptable for the residential and commercial receptors. Additionally, while arsenic was identified as a carcinogen resulting in unacceptable risks in Area A, there were only three soil samples (within the 0- to 15-foot-depth ranges evaluated in this HHRA) that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

Human Health Risk Assessment Results for Area B. The exposure pathways that were quantitatively evaluated at Area B were soil ingestion, dermal contact with soil, and inhalation of fugitive dust. No volatile organic compounds (VOCs) were detected in Area B soil or groundwater.

The assessment of carcinogenic risks to residential receptors at Area B indicated potential risks exceeded the DEQ acceptable risk level only under the RME condition. COPCs that exceed the DEQ acceptable risk level for individual carcinogens are benzo(a)pyrene and arsenic. The assessment of noncarcinogenic risks found no exceedences of DEQ acceptable risk levels for residential exposure.

For the commercial worker exposure scenario, the estimated cumulative carcinogenic risks were found to be acceptable under both RME and CT conditions. However, arsenic exceeded the DEQ acceptable risk level for individual carcinogens under the RME condition. The assessment of noncarcinogenic risks found no exceedences of DEQ acceptable risk levels for commercial worker exposure.

No unacceptable carcinogenic or noncarcinogenic risks were estimated for the excavation worker exposure in Area B.

Arsenic was identified as a carcinogen resulting in unacceptable risks in Area B for residential and commercial worker exposure scenarios. However, there were no detected concentrations of arsenic in soils in Area B that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

Human Health Risk Assessment Results for Area C. The exposure pathways that were quantitatively evaluated at Area C were soil ingestion, dermal contact with soil, and inhalation of fugitive dust. No VOCs were detected in Area C soil or groundwater. Arsenic is the only COPC for Area C.

The cumulative RME and CT carcinogenic risks for all potential receptors (resident, commercial worker, and excavation worker) in Area C were found to be acceptable with the exception of the RME residential scenario. Arsenic exceeded the DEQ individual carcinogen acceptable risk level for the RME residential and commercial worker scenarios. The assessment of noncarcinogenic risks found no exceedences of DEQ acceptable risk levels for all potential receptors. There were no detected concentrations of arsenic in surface soils (0 to 3 feet) in Area C that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

Ecological Risk Assessment Results. The Level 1 Scoping ERA did not identify any ecologically important species or habitats at the T1S Site. The site is almost entirely paved or covered by buildings. The absence of upland habitat indicates there are no complete exposure pathways for terrestrial ecological receptors to come in contact with contaminated soil at the T1S Site. In addition, based on the reasonably likely future use of the site (commercial and/or residential), future habitats on the site are not reasonably likely.

A Modified Level 2 Screening ERA was conducted on the available groundwater monitoring well data collected at this site. There were no detected concentrations of organic constituents in the seven groundwater monitoring wells that exceeded their corresponding Ecological Screening Benchmark Values (SBVs). There were two metals (copper and lead) detected in groundwater that exceeded SBVs based on the analysis of unfiltered, total metals, but when the same samples were analyzed for dissolved metals, copper and lead were not detected. The dissolved fraction of metals represents the bioavailable fraction in aqueous environmental media. Therefore, it is concluded that there is no potential for adverse ecological impacts to aquatic ecological receptors from the discharge of groundwater to the Willamette River.

2.5 Hot Spot Evaluation

As part of the evaluation of alternatives, the FS must distinguish between contamination that does and does not constitute a hot spot (OAR 340-122-085(5), (6), and (7) and OAR 340-122-090(4)). The definition and evaluation of hot spots differs depending on whether water (groundwater or surface water) or media other than water are being considered (media other than water include soil, debris, sediment, wastes, non-aqueous phase liquid, and other materials). In accordance with OAR 340-122-115(31), hot spots are defined as follows.

Groundwater or Surface Water. To be a hot spot in groundwater or surface water requires the following:

There is no surface water within the locality of the facility. Therefore, there is no surface water hot spot.

2.5.2 Media Other Than Groundwater or Surface Water

Hazardous substances (PAHs, lead, and arsenic) are present at the T1S Site. With the exception of two samples, individual carcinogenic risk estimates are less than 100 times the acceptable risk level (1×10^{-4}) and noncarcinogenic risk estimates are less than 10 times the acceptable risk level. Inspection of field logs did not identify indicators of free-phase petroleum hydrocarbons. Samples B-68 and B-92 had benzo(a)pyrene concentrations (7.05 mg/kg and 2.35 mg/kg, respectively) greater than the concentration corresponding to a risk level of 1×10^{-4} (2.1 mg/kg). Sample B-68 also had a lead concentration (6,190 mg/kg) greater than the Hot Spot Level (4,000 mg/kg). The B-68 and B-92 samples were collected from Area A and Area B, respectively (see Figure 2). In addition, PAHs are relatively immobile and are not likely to migrate (as supported by the lack of detections in groundwater). Therefore, soil hot spots (resulting from two soil samples) are present at B-68 and B-92.

3.0 BASIS OF FEASIBILITY STUDY ANALYSIS

In this section, we define the basis by which the FS was conducted. This includes defining the remedial action objectives, the criteria by which the alternatives were evaluated, and the areal and volumetric extent of the contamination to be addressed.

3.1 Remedial Action Objectives

The remedial action objectives are defined to address the unacceptable risks determined by the baseline risk assessment. These risks were reviewed in Section 2.3. In summary, there is an unacceptable risk to human receptors as follows:

Area A

- Future resident or commercial worker dermal contact or ingestion of soil with PAHs, lead, and arsenic; and
- Excavation worker dermal contact or ingestion of soil with lead.

Area B

- Future resident dermal contact or ingestion of soil with benzo(a)pyrene.

Therefore, the remedial action objective is:

- Prevent human contact or ingestion of soil impacted by PAHs, lead, and arsenic above the cleanup levels listed below.

| COPC | Residential Remedial Action Levels (mg/kg) | |
|------------------------|---|-----------------------------|
| | Cleanup Level ¹ | Hot Spot Level ² |
| PAHs | | |
| benzo(a)pyrene | 0.021 | 2.1 |
| benzo(a)anthracene | 0.21 | 21 |
| dibenz(a,h)anthracene | 0.021 | 2.1 |
| benzo(b)fluoranthene | 0.21 | 21 |
| indeno(1,2,3-cd)pyrene | 0.21 | 21 |
| Arsenic | 5.33 ³ | 38 ⁴ |
| Lead | 400 | 4,000 |

¹ Based on Human Health Risk Assessment (Hart Crowser, 2002a), except arsenic (see footnote 3).

² Calculated based on 100 times (carcinogens) or 10 times (noncarcinogens) the established Cleanup Level.

³ Based on Statistical Background Concentration (Hahn and Associates, 2001a).

⁴ Calculated based on 100 times the acceptable risk level. Arsenic residential soil acceptable risk level is 0.38 mg/kg (Region 9 Preliminary Remediation Goals [EPA, 2000]).

3.2 Evaluation Criteria

In accordance with OAR 340-122-085(4), the remedial alternatives are evaluated based on protectiveness, feasibility, and the extent to which the alternatives treat or remove hot spots of contamination. Protectiveness is determined using the standards in OAR 340-122-040. The protectiveness standards applicable to the T1S Site are summarized as follows:

- Ability of the remedial action to protect present and future public health, safety, and welfare and the environment;
- Ability of the remedial action to achieve acceptable risk levels specified in OAR 340-122-115(1);
- Ability of the remedial action to prevent or minimize future releases and migration of contaminants in the environment; and

- Provisions for long-term care or management, as necessary and appropriate, including but not limited to monitoring, operation, maintenance, and periodic review.

Feasibility of a remedial action is evaluated by balancing remedy selection factors contained in OAR 340-122-090(3) and (4). These balancing factors are summarized as follows:

- **Effectiveness** – ability and time-frame of remedial action to achieve protection through eliminating and managing risk.
- **Long-term reliability** – reliability of remedial action to eliminate or manage risk and associated uncertainties.
- **Implementability** – ease or difficulty of implementing remedial action considering technical, mechanical, and regulatory requirements.
- **Implementation risk** – potential impacts to workers, the community, and the environment during implementation.
- **Reasonableness of cost** - includes capital costs, operations and maintenance, periodic review, and net present value of the remedial action (a cost is not considered reasonable if the costs are disproportionate to the benefits created through risk reduction or risk management).

Treatment or Removal of Hot Spots. Treatment of hot spots is evaluated based on the criteria set forth in OAR 340-122-085(5) through (7). The portions of these rules applicable to the T1S Site are summarized as follows:

- Evaluate the extent to which the hazardous substance cannot be reliably contained;
- Evaluate the feasibility of treatment to a point where the hot spot would no longer occur (based on a balancing of the factors listed above) and an application of the higher threshold for evaluating the reasonableness of cost of treatment; and
- Evaluate the feasibility of treatment to the acceptable risk level without an application of the higher threshold for evaluating the reasonableness of cost of treatment.

3.3 Area and Volume of Contamination

Figure 3 shows the sample locations and identifies the areas exceeding the Cleanup Level or the Hot Spot Level. Two samples (B-68 and B-92) exceeded the Hot Spot Level for benzo(a) pyrene. Sample B-68 exceeded the Hot Spot

Level for lead. The estimated area and volume of soil and hot spots requiring remediation are as follows.

Total:

Area - 51,200 square feet (including the hot spot areas).

Depth - 3 feet except at B-38 and B-92. For a 30-foot diameter centered at B-38 and B-92, depth equal to 10 feet.

Volume - 6,100 cubic yards (including the hot spot volume).

Hot Spots:

Area - 1,420 square feet.

Depth - 3 feet at B-68 and 10 feet at B-92.

Volume - 340 cubic yards.

4.0 TECHNOLOGY EVALUATION AND REMEDIAL ACTION ALTERNATIVES

Initially, technologies associated with a list of general response actions were screened for applicability based on the ability to address the remedial action objectives. General response actions are broad categories of remedial measures that address the remedial action objectives. A response action may be a stand-alone remedial action alternative, or a component of a comprehensive alternative. The list of general response actions includes:

- No Action;
- Institutional Controls;
- Removal/Discharge;
- Containment;
- *In Situ* Biological Treatment;
- *In Situ* Physical/Chemical/Thermal Treatment;
- *Ex Situ* Biological Treatment; and
- *Ex Situ* Physical/Chemical/Thermal Treatment.

The first two columns of Table 1 list the general response actions with representative remedial action technologies. The list of potentially applicable technologies was developed from a wide range of sources including government documents, research literature, periodicals, the Internet, and our

experience. The third column of Table 1 includes a brief description of each technology and aids in the understanding of what each technology includes. The fourth column discusses the effectiveness of the technology or the conditions under which the technology may be effective. Comments in the last column explain the rationale for either accepting or eliminating a particular technology option. The shaded technologies in Table 1 are eliminated from further consideration. Remedial action technologies for soil retained for further consideration include:

- No Action;
- Access Restrictions;
- Monitoring of soil;
- Cover;
- Soil excavation;
- Off-site landfill disposal of soil; and
- Thermal desorption.

Several of these technologies are not useable without being combined with other technologies. As appropriate, technologies were combined to form functional alternatives (such as combining excavation with off-site disposal). Monitoring is considered to be part of each alternative except No Action. The No Action Alternative is kept through the screening process to serve as a baseline for comparison. Remedial action alternatives identified for detailed analysis include:

- No Action;
- Cover/Deed-restrictions with hot spot removal (Cover);
- Off-site landfill disposal (Landfill); and
- Soil treatment by thermal desorption/selective off-site landfill disposal (Thermal Treatment).

5.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section identifies and evaluates each of the remedial action alternatives identified in Section 4.0. Feasibility of the alternatives was evaluated using the criteria in Section 3.2.

Following the evaluation, a comparative analysis of each alternative relative to every other alternative was completed (Section 6.0). This comparative analysis serves as the basis for selecting the recommended remedial action alternative (Section 7.0). Estimated costs for each technology are included in Table 2.

5.1 No Action

Description. According to OAR 340-122-085 (2), a No Action Alternative must be evaluated as a remedial action alternative. The No Action Alternative assumes that no action is taken, no monitoring is performed, and no costs are incurred.

Protectiveness. The No Action Alternative is not protective because it allows contaminants to be left in place at concentrations that exceed protective levels.

Effectiveness. The No Action Alternative will not effectively manage risk.

Long-Term Reliability. The No Action Alternative will not reliably address the contamination or associated risk.

Implementability. The No Action Alternative is the easiest of the alternatives to implement.

Implementation Risk. Since there are no construction or remediation activities associated with the No Action Alternative, there is no risk to workers or the public during implementation of this alternative.

Reasonableness of Cost. There is no cost associated with the No Action Alternative.

Hot Spots. The No Action Alternative does not address hot spots.

5.2 Cover/Deed Restrictions with Hot Spot Removal

Description. On-site soil above Hot Spot Levels (B-68 and B-92) would be excavated, loaded in trucks, and hauled to a licensed Subtitle C (hazardous waste) or D (solid waste) landfill. Approximately 80 cubic yards in the vicinity of B-68 (elevated metal concentrations) would be excavated separately from soils in the vicinity of B-92 stockpiled for waste designation sampling (based on leachability of lead). If designated a hazardous waste, this soil would be disposed of at a licensed Subtitle C facility. Soils excavated in the vicinity of B-92 (approximately 260 cubic yards impacted primarily by PAH contamination) would be disposed of at a licensed Subtitle D disposal facility or treated at a licensed thermal treatment facility.

Clean, imported soil would be placed at the site to restore the ground surface to the previously existing grade. In addition to the hot spot removals and disposal, 51,200 square feet of impacted surface soils would be permanently capped. The area to be capped corresponds to the areas identified on Figure 3. For purposes of the feasibility study, the cap is assumed to consist of a typical commercial/industrial pavement section of 4 inches of asphalt concrete over 10 inches of crushed rock base course.

To complete this alternative, a deed restriction would be structured for the subject property. The deed restriction would notify owners or potential owners of the presence of the cap and identify associated restrictions. Site monitoring wells would be abandoned in accordance with Water Resource Department requirements.

Protectiveness. This alternative is protective of human health by removing hot spots to a controlled landfill and preventing direct contact with residual contamination in soil.

Effectiveness. This alternative addresses direct-contact risk as long as the cover is maintained and the deed restrictions are abided by. The time to reach the RAO is estimated to be two months.

Long-Term Reliability. Although this alternative does not reduce toxicity or mobility of the contamination in the soil, the hot spots would be removed to a controlled disposal facility and the cap would prevent direct contact with residual contamination in soil (as long as the integrity of the cover is maintained).

Implementability. The site is easy to access and this remedial action alternative is readily implemented using current and available construction techniques. Administration of the deed restriction will require recording of documents with the County.

Implementation Risk. Construction activities associated with this alternative are minimal and there is little risk during implementation if care is taken to prevent direct contact with the source soils. The primary potential impact to the community would be dust generation during excavation and spilling of soil or vehicular accidents during the transport to the landfill. Dust control would be used to decrease dust generation. Prior to departure from the site, all loose soil would be brushed from the truck or drop boxes. All trucks would be tarped to prevent incidental spilling during transport.

Reasonableness of Cost. The estimated cost for the Cover Alternative is \$288,000. This cost includes long-term costs for the maintenance of the cap. The scope of work and unit costs used to develop this estimate are summarized in Table 2.

Hot Spots. Hot spots are addressed by removal from the site and disposal in a licensed hazardous and/or solid waste landfills, as appropriate.

5.3 Off-Site Landfill Disposal

Description. Soil above human health risk levels (except in the vicinity of B-38 and B-68) would be excavated, loaded in trucks, and hauled to a Subtitle D solid waste landfill. This removal volume is estimated to be approximately 5,730 cubic yards. This quantity includes the hot spot soil at B-92. The soils in the vicinity of B-38 and B-68 (elevated metal concentrations) would be excavated separately and stockpiled for waste designation sampling (based on leachability of lead). If designated a hazardous waste, this soil (about 340 cubic yards) would be loaded in trucks and hauled to a Subtitle C hazardous waste landfill. Otherwise, the soil would be disposed of with the remaining site soil. The areas/depths of soil excavation are shown on Figure 3.

Clean, imported soil would be placed at the site to restore the ground surface to previously existing grade. Dust control would be achieved at the site by spray application of water to the ground surface as needed. There would be no long-term maintenance requirements with this alternative. Site monitoring wells would be abandoned in accordance with Water Resource Department requirements.

Protectiveness. Landfill disposal achieves protection by removing contaminated soil above acceptable risk levels (including hot spots) to a controlled landfill.

Effectiveness. This alternative is very effective. Disposing of the soil at a landfill will eliminate the human health risk from the soil by removing the contaminated source to a managed facility. The time estimated to reach the RAO is estimated to be one to two months.

Long-Term Reliability. Landfill disposal does not reduce the toxicity or mobility of the contaminants. This alternative otherwise has good long-term reliability because the landfill is a controlled disposal facility that will be required to conduct long-term maintenance and monitoring.

Implementability. The site is easy to access and this remedial action alternative is readily implemented using current and available construction techniques. Transportation time and distance to the landfill is manageable. Limited shoring

polynuclear aromatic hydrocarbons (PAHs) on the site through treatment of the contaminated soil.

Effectiveness. This alternative is very effective. It achieves effectiveness through removing the contaminated soil to a managed facility or treatment of the contaminant. The time estimated to reach the RAOs is estimated to be 1 to 2 months.

Long-Term Reliability. This alternative offers good long-term reliability because contaminated soil is removed from the T1S Site. Landfill disposal does not reduce the toxicity or mobility of the contaminants. Overall, this alternative has good long-term reliability because (1) the landfill is a controlled disposal facility that will be required to conduct long-term maintenance and monitoring, and (2) thermal desorption provides complete destruction of the contaminant.

Implementability. The site is easy to access and this remedial action alternative is readily implemented using current and available construction techniques. Transportation time and distance to the thermal desorption and landfill facilities are manageable. Limited shoring may be required for the deeper excavations near Naito Parkway and House No. 104. Mobile desorption units are available.

Implementation Risk. This alternative poses little threat to workers or the community during construction. The primary potential impact to the community would be dust generation during excavation and spilling of soil or vehicular accidents during the transport to the landfill or treatment facility. There is less risk than for the Landfill Alternative because the thermal facility is closer. Dust control would be used to decrease dust generation. Prior to departure from the site, all loose soil would be brushed from the truck or drop boxes. All trucks would be tarped to prevent incidental spilling during transport.

Reasonableness of Cost. The estimated cost for the Thermal Treatment Alternative is \$564,000. The scope of work and unit costs used to develop this estimate are summarized in Table 2.

Hot Spots. Hot spots are addressed by complete removal from the site. Metals hot spots would be disposed of in licensed hazardous and/or solid waste landfills. The remaining hot spot would be treated in the thermal desorption unit.

6.0 COMPARATIVE EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section of the FS presents an evaluation of the remedial action alternatives in relation to one another. The comparative analysis is summarized in Table 3. In the table, each alternative is compared to each of the other alternatives for each

evaluation criteria. An alternative is ranked as favorable (+), equal (0), or unfavorable (-) in relation to every other alternative. The scores are summed at the right of the table for each alternative and then ranked. The following discussion provides a rationale for the comparative evaluation presented in Table 3.

Protectiveness. This criterion is pass/fail. An alternative must be protective as defined by OAR 340-122-040 to be acceptable. With the exception of the No Action Alternative, all of the remedial actions meet the protectiveness criteria. The alternatives were not scored based on this criterion, but protectiveness was considered when ranking the alternatives in the right-hand column.

Effectiveness. The alternatives were ranked based on the permanency of the alternative and the time required to complete the remedial action. The Landfill and Thermal Treatment Alternatives are essentially permanent and require the same length of time (equally ranked). The Cover Alternative ranked next, with No Action last.

Long-term Reliability. Alternatives that permanently treat the contamination ranked highest. The Thermal Treatment Alternative was ranked higher than the Landfill Alternative because a substantial portion of the removal volume would be treated by thermal desorption (permanently destroying the contaminants). The Cover Alternative is ranked the second lowest because only a small portion of the contaminant volume (i.e., hot spot volume) is removed from the site. The No Action Alternative was not considered a reliable remedial alternative.

Implementability. The No Action Alternative was considered the most easily implemented remedial action. The soil removal alternatives were considered to be equally implementable because they both use similar construction methods. There is uncertainty involved as to the ease of implementation of the cover alternative because of the need for institutional controls. Therefore, the Cover Alternative was ranked the lowest.

Implementation Risk. The No Action Alternative carries no implementation risk. Because implementation risk is primarily a function of excavation quantities and transport of contamination on roadways, alternatives with less excavation (Cover) ranked higher and alternatives with shorter haul distances (Thermal Treatment) ranked next. Therefore, the Landfill Alternative ranked last.

Reasonableness of Cost. Cost estimates were developed for each of the remedial options based on capital and long-term costs. The following list summarizes the present worth total cost estimates for each alternative.

- No Action (\$0);
- Cover (\$288,000);
- Landfill (\$559,000); and
- Thermal Treatment (\$564,000).

Hot Spots. All of the alternatives except No Action address hot spots by thermal treatment and/or removal from the site.

7.0 RECOMMENDATIONS AND RESIDUAL RISK ASSESSMENT

Recommendations. We recommend the implementation of either the Landfill or Thermal Treatment Alternatives. Either of these alternatives:

- Is protective of public health, safety, and welfare and the environment by preventing exposure of receptors to the contaminants;
- Balances remedy selection factors; and
- Addresses hot spots by removal to an off-site landfill or treatment by thermal desorption.

In the comparative analysis (Table 3), the Thermal Treatment Alternative scored higher overall. The difference between the Thermal and Landfill Alternatives focused on long-term reliability, implementation risk, and cost. Of these, implementation risk is low overall for any of these alternatives. If the implementation risk criterion is not considered, the Landfill and Thermal Treatment Alternatives score equally. In this case, we would recommend selecting the lower-cost alternative at the time of construction.

Residual Risk Assessment. The baseline human health risk assessment identified unacceptable carcinogenic risks in Areas A, B, and C under the residential and commercial worker scenario. Predicted unacceptable risks resulted from the potential ingestion and dermal contact with soil containing PAHs, lead, and arsenic. Upon implementation of the recommended alternative, the total site risk would be reduced with the removal of soil contaminated above hot spot levels, established cleanup levels, and the regional background level for arsenic. We estimated the magnitude of the risk remaining on-site after remediation by removing the data corresponding to samples in the cleanup areas from the database and re-calculating the predicted residual risk for each receptor scenario and area of the site. The predicted residual risk is summarized as follows.

Area A. The residual risk assessment found that the carcinogenic risk to future residential and commercial workers from exposure to individual carcinogens under the RME condition exceeded DEQ acceptable risk level of 1×10^{-6} . Additionally, the RME cumulative carcinogenic acceptable risk level of 1×10^{-5} was exceeded for future residents. The cumulative RME excess lifetime cancer risk for future residents, future commercial workers, and excavation workers are 4×10^{-5} , 4×10^{-6} , and 1×10^{-8} , respectively. However, all of the unacceptable risk estimates for Area A resulted from exposure to the RME EPC for arsenic in soil, based on the maximum detected concentration of arsenic in area A of 7.53 mg/kg. If the mean (or CT) value for arsenic in soil in Area A were used to calculate carcinogenic risks, all of the predicted residual risk, both for individual and cumulative carcinogenic risks under either future use scenario would be acceptable.

While arsenic was identified as a carcinogen resulting in unacceptable risks in Area A, there were only three samples (B-11, B-68, and B-97) within the 0- to 15-foot-depth ranges that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

Soil in the vicinity of sample location B-68 will be removed as part of proposed remedial activities at the site. Soil at sample location B-11 (9–11 bgs) was included in the calculation of risk under the excavation worker scenario. Soil at sample location B-97 (7.5 mg/kg, 2.5 bgs) located under the Naito Parkway would be accessed only under the excavation worker scenario. Risks calculated under the excavation worker scenario in Area A were within acceptable levels.

The cumulative RME HI for future residents, future commercial workers, and excavation workers are 0.8, 0.03, and 0.005, respectively. Cumulative RME HI's were all acceptable according to DEQ's target risk levels as they were all less than the acceptable value of 1.

Area B. The residual risk assessment found that the carcinogenic risk to future residential and commercial workers from exposure to individual carcinogens under the RME condition exceeded DEQ acceptable risk level of 1×10^{-6} . Additionally, the RME cumulative carcinogenic acceptable risk level of 1×10^{-5} was exceeded for future residents. The cumulative RME excess lifetime cancer risk for future residents, future commercial workers, and excavation workers are 1×10^{-5} , 2×10^{-6} , and 9×10^{-8} , respectively. However, all of the unacceptable risk estimates for Area B resulted from exposure to the RME EPC for arsenic in soil, based on the maximum detected concentration of arsenic in Area B soils. If the mean (or CT) value for arsenic in Area B soils were used to calculate carcinogenic risks, all of the predicted residual risk, both for individual and

cumulative carcinogenic risks under either future use scenario would be acceptable.

While arsenic was identified as a carcinogen resulting in unacceptable future risks in Area B, there were no detected concentrations of arsenic in soils that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

The cumulative RME HI for future residents, future commercial workers, and excavation workers are 0.4, 0.11, and 0.003, respectively. Cumulative RME HI's were all acceptable according to DEQ's target risk levels as they were all less than the acceptable value of 1.

Area C. The residual risk assessment found that the carcinogenic risk to future residential and commercial workers from exposure to individual carcinogens under the RME condition exceeded DEQ acceptable risk level of 1×10^{-6} . Additionally, the RME cumulative carcinogenic acceptable risk level of 1×10^{-5} was exceeded for future residents. The cumulative RME excess lifetime cancer risk for future residents, future commercial workers, and excavation workers are 2×10^{-5} , 2×10^{-6} , and 5×10^{-8} , respectively. However, all of the unacceptable risk estimates for Area C resulted from exposure to the RME EPC for arsenic in soil, based on the maximum detected concentration of arsenic in Area C soils. If the mean (or CT) value for arsenic in Area C soils were used to calculate carcinogenic risks, all of the predicted residual risk, both for individual and cumulative carcinogenic risks under either future use scenario would be acceptable.

While arsenic was identified as a carcinogen resulting in unacceptable future risks in Area C, there were no detected concentrations of arsenic in soils that exceeded the site-specific background level of 5.3 mg/kg identified in the RI (Hahn and Associates, 2001a).

The cumulative RME HI for future residents, future commercial workers, and excavation workers are 0.3, 0.01, and 0.009, respectively. Cumulative RME HI's were all acceptable according to DEQ's target risk levels as they were all less than the acceptable value of 1.

Risk and hazard estimate calculations for each area (except Area C), exposure pathways, and receptors are presented in Appendix A (Tables A-1 through A-7). The revised exposure point concentrations are presented in Table A-7. Table A-8 presents the sum of risk and hazards associated with each individual exposure pathway, while Table A-9 presents the RME carcinogenic risk estimates as a sum of risks associated with each COPC.

Residual risk calculations were not performed for Area C. Risk and hazard estimate calculations for Area C, exposure pathways, and receptors are provided in Appendix B of the Human Health and Ecological Baseline Risk Assessment (Hart Crowser, 2002a). The sum of risk and hazards associated with each individual exposure pathway for Area C is included in Table A-8 and the RME carcinogenic risk estimates as a sum of risks associated with each COPC for Area C is summarized in Table A-9.

8.0 REFERENCES

- DEQ, 1998. Guidance for Conducting Feasibility Studies. July 1, 1998.
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**Table 1 - Initial Screening and Evaluation of Technologies for Soil Feasibility Study
Terminal 1 South
Portland, Oregon**

| General Response Action | Technology | Description | Effectiveness | Screening Comments |
|---|--|--|---|---|
| NO ACTION | None | No Action | Not Effective | Retained as a baseline for comparison. |
| INSTITUTIONAL CONTROL | Access Restriction | Restrict access with physical and/or legal barriers. | Effective at preventing direct contact. | Applicable in conjunction with other technologies. |
| | Monitoring | Laboratory analyses of soil samples. | Effective for documenting conditions and concentrations of contaminants remaining in the soil. | Applicable to document effectiveness of other treatment technologies. |
| REMOVAL | Excavation | Removal of contaminated soil, using conventional equipment or specialized methods where needed. | Effective to depths of up to 20 to 30 feet, but may require dewatering and/or shoring for depths over a few feet. | Applicable to shallow source soils. |
| | Disposal | Disposal of excavated soils in suitable landfill. | Effective, but does not reduce volume or toxicity of contamination. | Applicable for handling excavated soils. May have future liability. |
| CONTAINMENT | Cover | Cover area of contaminated soil with impervious (or semi-permeable) cover. | Effective at preventing direct contact. May reduce mobilization of contaminants (reduction of precipitation infiltration). | Applicable to minimize direct contact with contaminated soil. |
| IN-SITU BIOLOGICAL TREATMENT | Bioventing | Delivering oxygen to contaminated (unsaturated) soils by forced air movement to stimulate biodegradation. | Effective for non-chlorinated hydrocarbons or vinyl chloride. May interfere with anaerobic activity. | Incompatible with site-specific contaminants, particularly metals. |
| | Enhanced Bioremediation | Adding nutrients, electron donors, or other amendments to enhance bioremediation. | Effective with addition of suitable amendments, usually in conjunction with source removal. Difficult to ensure adequate coverage. | Applicable for limited treatment of PAHs. Metals not addressed. |
| | Land Treatment | Combination of aeration (tiling) and amendments to enhance bioremediation in surface soils. | Effective for shallow (surface) contamination with addition of suitable amendments. Requires sufficient access for soil equipment movement. | Incompatible with anticipated future site use. |
| | Natural Attenuation | Using natural processes to reduce contaminant concentrations to acceptable levels. | May be effective, especially in areas of low concentrations (near plume boundaries), but is dependent upon site conditions. Usually in conjunction with source removal. | Not suitable for short-term remediation of source area. Not applicable to metals or heavy hydrocarbons. |
| | Phytoremediation | Using plants to remove, transfer, elaborate, or destroy contaminants in soil. | May be effective for shallow contamination with concentrations below toxic thresholds for selected plants. Requires surface area suitable for plant growth. | Incompatible with anticipated future site use. |
| IN-SITU PHYSICAL/CHEMICAL/THERMAL TREATMENT | Electromagnetic Separation | Use of electrochemical/electromagnetic processes to disperse and remove metals and polar organics. | Can be effective in low permeability soils (clays) with highly polar contaminants. Used in conjunction with other removal technologies (such as groundwater pumping) to extract mobilized contaminants. | Ineffective with the combination of coarser grained site soils and low levels of contamination. |
| | Fracturing | Development of cracks in low permeability or over-consolidated soils to create passageways that increase the effectiveness of other in-situ processes and extraction technologies. | Effective in increasing influence radius of other in-situ technologies. May bypass significant contamination between cracks. | Not necessary with site soil conditions. Difficult to remove contaminants in non-fractured zones. |
| | Soil Flushing | Circulation of water (or water-based slurry) through contaminated soil mass. Recovered water is treated and recycled. | Most effective in treatment of inorganic contaminants. Use of surfactants to increase organic solubility may alter physical/chemical properties of soil system. | Less effective for organic contaminants. |
| | Soil Vapor Extraction | Application of a vacuum in extraction wells to induce gas-phase volatiles to be removed from the soil. | Effective for the removal of volatile organics. Less effective in fine-grained soils. | Incompatible with site-specific contaminants. |
| | Soil Solidification/Stabilization | Physically binding contaminants within a stabilized mass or inducing chemical reactions that reduce mobility. | Can be effective at reducing migration/toxicity of contaminants. Chemical additives may have long-term leaching issues or incompatibility with polynuclear aromatic hydrocarbons or metals. | Difficult to ensure complete coverage. |
| | Thermally Enhanced Soil Vapor Extraction | Applying heat (steam, hot air, heating units, directed energy) to increase volatilization rate of less volatile chemicals. | Effective for increasing usability of SVE for low volatility compounds. High moisture content or saturated conditions will decrease effectiveness. | Incompatible with site-specific contaminants. |

Please refer to note at end of table.

Table 1 - Initial Screening and Evaluation of Technologies for Soil Feasibility Study Terminal 1 South Portland, Oregon

| General Response Action | Technology | Description | Effectiveness | Screening Comments |
|--|---|---|---|---|
| IN-SITU PHYSICAL/CHEMICAL/ THERMAL TREATMENT (CONTINUED) | Chemical Reduction/Oxidation | Chemically converts hazardous contaminants to less toxic compounds. | Effective in destroying organic contaminants (including free product) and oxidizing inorganic contaminants to less toxic, less mobile forms. Difficult to provide adequate coverage in subsurface. | Applicable for treatment of PAHs; metals not addressed. Insufficient oxygen/burden pressure for efficient reduction/oxidation (in vicinity of contamination within 3 feet of ground surface). |
| | Bio-piles | Mixing soil amendments into excavated soil and placing in aerated piles. | Effective at removing many organic contaminants from excavated soil. Requires excavation of soil and area for both soil piles and pile handling. | Land use requirements are not compatible with anticipated future site use. |
| | Composting | Excavated soil is mixed with bulking agents and organic amendments to promote microbial activity. | Effective at removing many organic contaminants from excavated soil. Requires excavation of soil and area for both soil piles and pile handling. | Land use requirements are not compatible with anticipated future site use. |
| | Landfarming | Excavated soil is placed in lined beds and periodically tilled to aerate the soil. | Effective at removing many volatile organic contaminants from excavated soil. Bioactivity is uncontrolled and less effective. Requires excavation of soil and area for both soil piles and pile handling. | Land use requirements are not compatible with anticipated future site use. |
| EX-SITU PHYSICAL/CHEMICAL/ THERMAL TREATMENT | Slurry Phase Biological Treatment | A slurry of soil and water with additives is continuously mixed to keep solids suspended and microorganisms in contact with soil contaminants. | Effective at removing many organic contaminants from excavated soil. Requires excavation of soil and area for both soil piles and pile handling. Wastewater requires additional treatment. | Handling of slurry and wastewater is complicated and expensive. Land use requirements are not compatible with anticipated future site use. |
| | Chemical Extraction | Excavated soil is mixed with an extractant which dissolves the contaminants. The resultant solution is placed in a separator to remove the contaminant; extractant is recycled for treatment. | Can be effective in removing most organic contaminants from soil. Difficult to remove all contaminant/extractant mixture from soil. Would likely require further treatment. Contaminant/extractant mixture requires additional treatment. | Not as effective for relatively low levels of PAHs and metals found in site soils since additional treatment would be required for both soil and recovered extractant. |
| | Chemical Reduction/Oxidation | Chemically converts hazardous contaminants to less toxic compounds. | Effective in destroying organic contaminants (including free product) and oxidizing inorganic contaminants to less toxic, less mobile forms. Difficult to provide adequate coverage in subsurface. | Space requirements for reactor and soil handling not compatible with anticipated future site use. |
| | Dehalogenation | Benignants are mixed with excavated soils contaminated with halogenated organics. | Most suited to the treatment of halogenated semi-volatile organics and pesticides. | Incompatible with site-specific contaminants. |
| | Soil Washing | Contaminants are separated from the excavated soil with wash water augmented with additives to help remove organics. | Most suited to the treatment of semi-volatile organics, metals, and salts. Recovered wash water requires additional treatment. | Additional treatment would be required for recovered wastewater. |
| | Soil Vapor Extraction | Application of a vacuum in a network of above-ground piping to induce gas phase volatiles to be removed from the soil. | Effective for the removal of volatile organics. Less effective in fine-grained soils. | Incompatible with site-specific contaminants. |
| | Solar Detoxification | Contaminants are destroyed by photochemical and thermal reactions using Ultra-violet energy from light. | Can be effective for the detoxification of many organic compounds. Requires suitable climate and adequate space. | Land use requirements are not compatible with site space restrictions. Climate not suitable for long-term solar exposure. Not effective for metals. |
| | Stabilization/Solidification | Physically binding contaminants within a stabilized mass or inducing chemical reactions that reduce mobility. | Can be effective at reducing mobility/toxicity of contaminants. May be required to allow off-site disposal. | Not likely required for disposal, but may be required in conjunction with on-site disposal, depending on conductivity of excavated soil. |
| | Thermal Desorption/Pyrolysis/ Hot Gas Decontamination | Waste soils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated. | Effective in the treatment of soils contaminated with volatile organics. Limitations exist on contaminant concentrations, especially for chlorinated hydrocarbons. | Facilities exist that can thermally treat excavated soil. Acceptability will depend on concentration of metals in excavated soil (limited by the treatment facility). |
| | Incineration | High temperatures are used to combust organic contaminants. | Effective in the treatment of soils contaminated with volatile organics. | Facilities exist that can incinerate excavated soil containing petroleum hydrocarbons but are very distant from the site and quite expensive. Not required to treat TPH soils on a regular basis. |

Note:

1. Shading represents technologies that have been eliminated from consideration.

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Table 2 - Estimated Costs for Individual Remedial Action Alternatives**Feasibility Study****Terminal 1 South****Portland, Oregon**

| | Quantity | Unit | Unit Cost | Extension |
|--|-------------------------------------|----------|-----------|------------------|
| No Action | | | | |
| | Entire Site Estimated Cost | | | \$0 |
| Cover/Deed Restriction with Hot Spot Removal | | | | |
| Capital Costs | | | | |
| Deed Restriction | 1 | ls | \$15,000 | \$15,000 |
| Abandon Wells | 7 | well | \$1,000 | \$7,000 |
| Mobilization Earthmoving Equipment | 1 | ls | \$10,000 | \$10,000 |
| Excavation | 480 | tons | \$2 | \$960 |
| Backfilling | 480 | tons | \$10 | \$4,800 |
| Site Grading | 1.2 | acre | \$2,000 | \$2,400 |
| Base Course | 3,300 | tons | \$10 | \$33,000 |
| Asphalt Concrete Pavement | 51,200 | sf | \$1 | \$51,200 |
| Haul to Landfill Non-Hazardous | 370 | tons | \$7.5 | \$2,775 |
| Disposal Landfill Non-Hazardous | 370 | tons | \$30 | \$11,100 |
| Haul to Landfill Hazardous | 110 | tons | \$21 | \$2,310 |
| Disposal Landfill Hazardous | 110 | tons | \$120 | \$13,200 |
| Dust Control | 10 | day | \$150 | \$1,500 |
| Design/Work Plan/Procurement | 1 | lump sum | \$20,500 | \$20,500 |
| Subcontractor Oversight | 10 | day | \$1,500 | \$15,000 |
| Report | 1 | lump sum | \$8,000 | \$8,000 |
| 10% Contingency on Capital Cost | | | | \$19,875 |
| | Total Capital Cost | | | \$218,700 |
| Long-Term Costs (Present Value*) | | | | |
| Cover Maintenance | 30 | years | \$3,000 | \$35,500 |
| Engineering Oversight | 30 | years | \$2,500 | \$29,600 |
| 5% Contingency on LT Cost | | | | \$3,255 |
| | Present Worth Long-Term Cost | | | \$68,400 |
| | Entire Site Estimated Cost | | | \$288,000 |
| Excavation/Off-site Landfill Disposal | | | | |
| Mobilization Earthmoving Equipment | 1 | ls | \$10,000 | \$10,000 |
| Abandon Wells | 7 | well | \$1,000 | \$7,000 |
| Excavation | 8,500 | tons | \$2 | \$17,000 |
| Backfilling | 8,500 | tons | \$8 | \$68,000 |
| Haul to Landfill Non-Hazardous | 8,020 | tons | \$7.5 | \$60,150 |
| Disposal Landfill Non-Hazardous | 8,020 | tons | \$28 | \$224,560 |
| Haul to Landfill Hazardous | 480 | tons | \$21 | \$10,080 |
| Disposal Landfill Hazardous | 480 | tons | \$120 | \$57,600 |
| Dust Control | 15 | day | \$150 | \$2,250 |
| Design/Work Plan/Procurement | 1 | lump sum | \$20,500 | \$20,500 |
| Subcontractor Oversight | 15 | day | \$1,500 | \$22,500 |
| Report | 1 | lump sum | \$8,000 | \$8,000 |
| 10% Contingency on Capital Cost | | | | \$50,764 |
| | Entire Site Estimated Cost | | | \$559,000 |
| Excavation/Soil Treatment by Thermal Desorption | | | | |
| Mobilization Earthmoving Equipment | 1 | ls | \$10,000 | \$10,000 |
| Abandon Wells | 7 | well | \$1,000 | \$7,000 |
| Excavation | 8,500 | tons | \$2 | \$17,000 |
| Backfilling | 8,500 | tons | \$8 | \$68,000 |
| Haul to Landfill Hazardous | 480 | tons | \$21 | \$10,080 |
| Disposal Landfill Hazardous | 480 | tons | \$120 | \$57,600 |
| Haul to Thermal Desorption | 8,020 | tons | \$4.5 | \$36,090 |
| Treatment | 8,020 | tons | \$32 | \$256,640 |
| Dust Control | 15 | day | \$150 | \$2,250 |
| Design/Work Plan/Procurement | 1 | lump sum | \$20,500 | \$20,500 |
| Subcontractor Oversight | 15 | day | \$1,500 | \$22,500 |
| Report | 1 | lump sum | \$5,000 | \$5,000 |
| 10% Contingency on Capital Cost | | | | \$51,266 |
| | Entire Site Estimated Cost | | | \$564,000 |

F:\DATA\Job\Port of Portland\15230 Term 1 Support\FS\Table 2

Note:

* Present value costs calculated with an annual discount of 7.5 percent.

Table 3 - Comparison of Remedial Action Alternatives
Feasibility Study
Terminal 1 South

| Alternative | Effectiveness | | | | Long-Term Reliability | | | | Implementability | | | | Implementation Risk | | | | Cost | | | | Score | Rank |
|--|---------------|---|---|---|-----------------------|---|---|---|------------------|---|---|---|---------------------|---|---|---|------|---|---|---|-------|------|
| Soil | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | | |
| A No Action | | - | - | - | | - | - | - | | + | + | + | | + | + | + | | + | + | + | 3 | 4 |
| B Cover/Deed Restriction with Hot Spot Removal | + | | - | - | + | | - | - | - | | - | - | - | | + | + | - | | + | + | -3 | 3 |
| C Off-Site Landfill Disposal | + | + | | 0 | + | + | | - | - | + | | 0 | - | - | | - | - | | + | | -1 | 2 |
| Treatment by Thermal Desorption/Limited Off-site Landfill Disposal | + | + | 0 | | + | + | + | | - | + | 0 | | - | - | + | | - | - | - | | 1 | 1 |

obs\Port of Portland\15230 Term 1 Support\FS\Table 1 and 3

Notes:

+ = The alternative is favored over the compared alternative (score=1)

0 = The alternative is equal with the compared alternative (score=0)

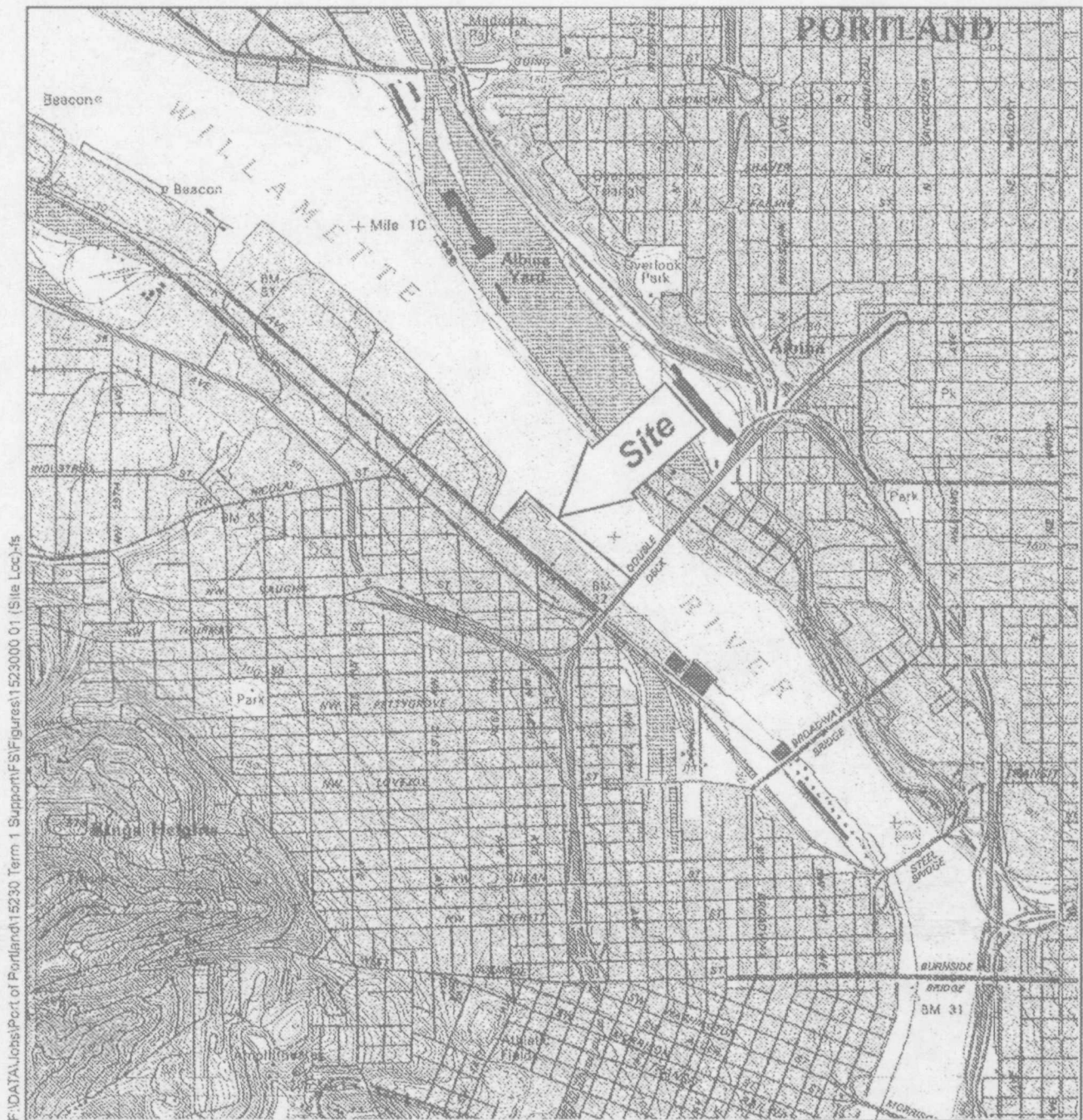
- = The alternative is less favorable than the compared alternative (score=-1)

Rank based on both protectiveness and balancing factors.

Key to Comparison Grid

| Criteria | | | | |
|--------------|---|---|---|---|
| Technology A | | B | C | D |
| Technology B | A | | C | D |
| Technology C | A | B | | D |
| Technology D | A | B | C | |

Site Location Map
Terminal 1 South Feasibility Study
Port of Portland, Portland, Oregon



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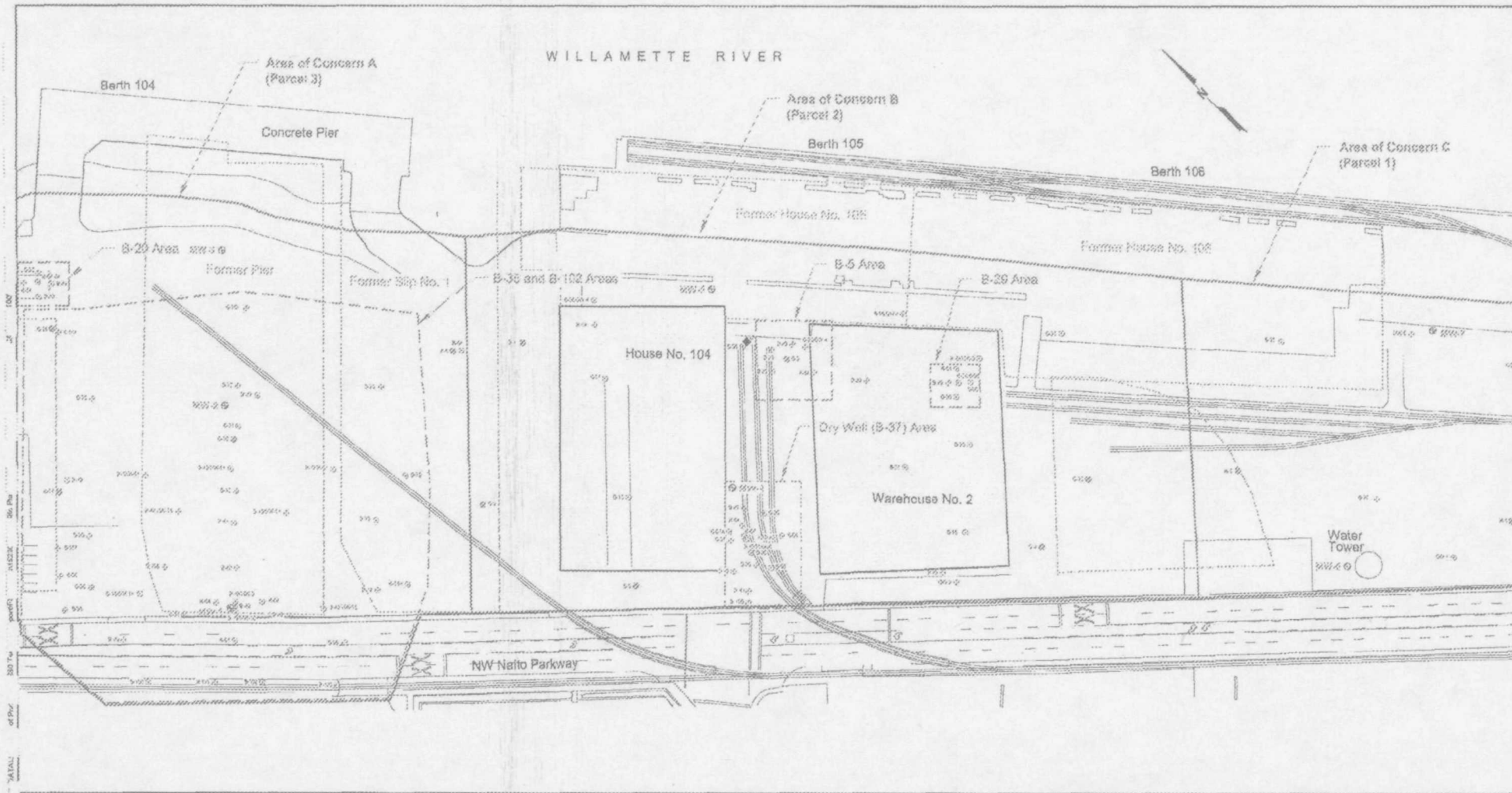
Note: Base map prepared from the USGS 7.5-minute quadrangle of Portland, OR dated 1990.



0 2,000 4,000
 Scale in Feet
 Contour Interval 10 Feet

HARTCROWSER
 15230 3/02
 Figure 1

Site Plan
Terminal 1 South Feasibility Study
Port of Portland, Portland, Oregon



Note: Base map prepared from an AutoCAD file provided by Olson Engineering, 8/27/01.

Legend:

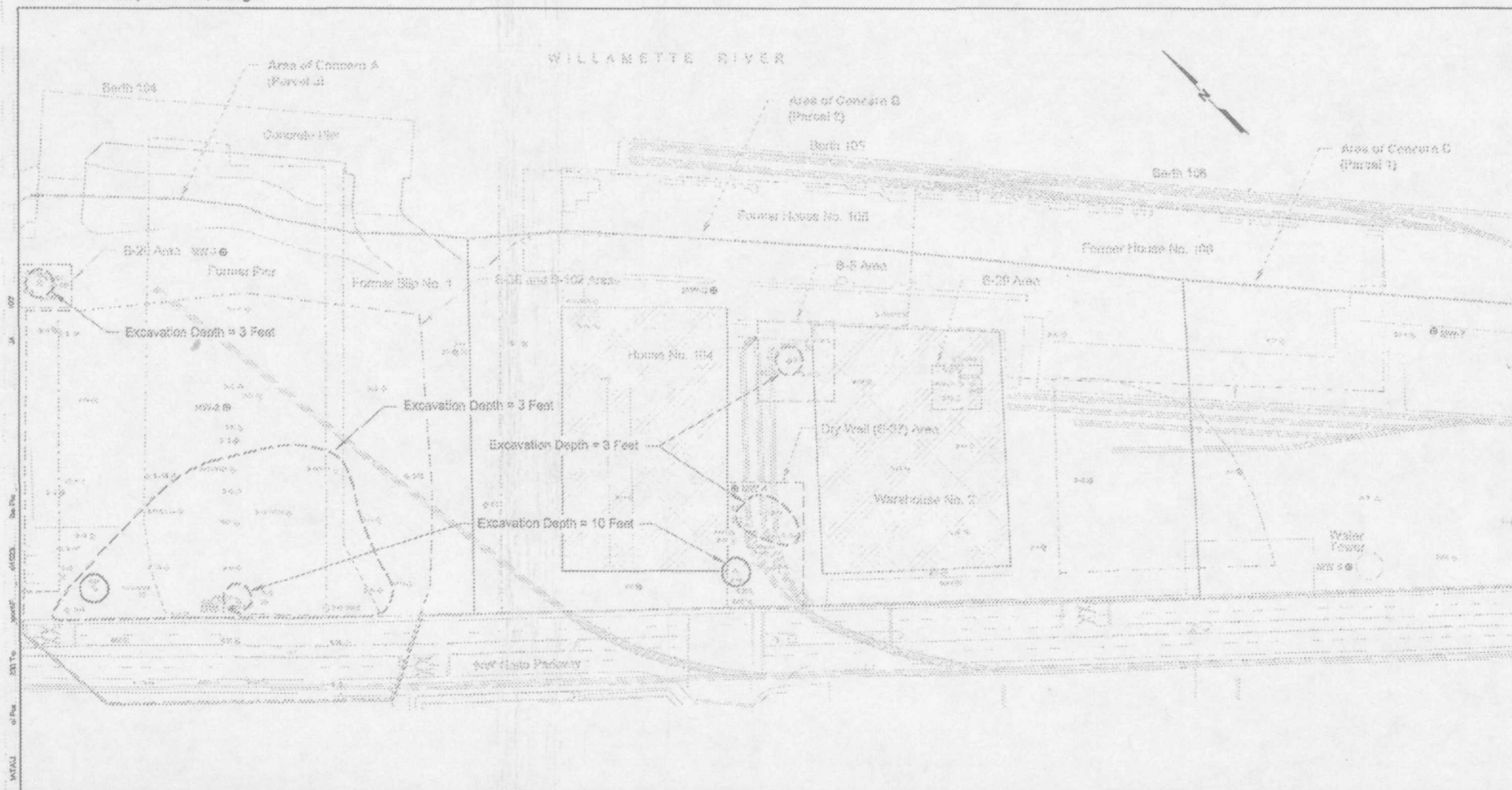
- Maui Foster and Alongi, Inc. Push Probe Boring Location and Number (March 1998)
- HAI Monitoring Well Location and Number (2001)
- HAI Push Probe Boring Location and Number (2000)

0 100 200
 Approximate Scale in Feet

HART CROWSER
 15230
 Figure 2
 3/02

POPT1S600896

Location of Soil Above Cleanup or Hot Spot Levels
Terminal 1 South Feasibility Study
Port of Portland, Portland, Oregon



Note: Base map prepared from an AutoCAD file provided by Olson Engineering, 8/27/01.

Legend:

- Maul Foster and Alongi, Inc. Push Probe Boring Location and Number (March 1998)
- HAI Push Probe Boring Location and Number (2000)
- ⊙ HAI Monitoring Well Location and Number (2001)

- Soil Above Remedial Action Levels
- Soil Exceeding Hot Spot Level

0 100 200
 Approximate Scale in Feet

HARTCROWSER
 15230 3/02
 Figure 3

POPT1S600897

APPENDIX A
RESIDUAL RISK ASSESSMENT TABLES

Table A-1 - Area A Risk Calculations
Soil Ingestion, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------|----------------------------|---------|-------------|---------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | |
| Arsenic | 7.5E+00 | 2.4E+00 | 1.9E-04 | 1.8E-06 | 6.4E-01 | 5.8E-03 | 2.0E-05 | 1.6E-07 | 3.0E-05 | 2.4E-07 |
| TOTAL HAZARD INDEX | | | | | 6.E-01 | 6.E-03 | TOTAL CANCER RISK | | 3.E-05 | 2.E-07 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-1 - Area A Risk Calculations
Dermal Contact with Soil, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 7.5E+00 | 2.4E+00 | 7.2E-05 | 7.1E-07 | 2.4E-01 | 2.4E-03 | 6.8E-06 | 6.3E-08 | 1.0E-05 | 9.4E-08 |
| TOTAL HAZARD INDEX | | | | | | 2.E-01 | 2.E-03 | TOTAL CANCER RISK | | 1.E-05 | 9.E-08 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-1 - Area A Risk Calculations
Vapor Inhalation (Indoor Air), Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|-----------------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Volatile Organic Compounds | | | | | | | | | | |
| Tetrachloroethene | 1.2E-05 | 1.2E-05 | 6.4E-06 | 6.4E-06 | 7.6E-05 | 7.6E-05 | 1.4E-06 | 6.5E-07 | 3.6E-09 | 1.7E-09 |
| TOTAL HAZARD INDEX | | | | | 8.E-05 | 8.E-05 | TOTAL CANCER RISK | | 4.E-09 | 2.E-09 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-1 - Area A Risk Calculations
Fugitive Dust Inhalation, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF In m ³ /kg | Air EPC In mg/3 | | Hazard Intake In mg/kg-day | | Hazard Quotient | | Cancer Intake In mg/kg- day | | Cancer Risk | |
|-----------------------------------|------------------------------|-----------------|---------|----------------------------|---------|-----------------|--------|--------------------------------|---------|-------------|---------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 1.32E+09 | 5.7E-09 | 1.8E-09 | 3.0E-09 | 9.6E-10 | -- | -- | 6.7E-10 | 9.9E-11 | 1.0E-08 | 1.5E-09 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 1.E-08 | 1.E-09 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-2 - Area A Risk Calculations
Soil Ingestion, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|-----------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | |
| Arsenic | 7.5E+00 | 2.4E+00 | 7.4E-06 | 1.2E-06 | 2.5E-02 | 3.9E-03 | 2.6E-06 | 1.0E-07 | 3.9E-06 | 1.5E-07 |
| TOTAL HAZARD INDEX | | | | | 2.E-02 | 4.E-03 | TOTAL CANCER RISK | | 4.E-06 | 2.E-07 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-2 - Area A Risk Calculations
Dermal Contact with Soil, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------|----------------------------|---------|-------------|---------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 7.5E+00 | 2.4E+00 | 7.3E-07 | 1.8E-07 | 2.4E-03 | 6.0E-04 | 2.6E-07 | 1.5E-08 | 3.9E-07 | 2.3E-08 |
| TOTAL HAZARD INDEX | | | | | | 2.E-03 | 6.E-04 | TOTAL CANCER RISK | | 4.E-07 | 2.E-08 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-2 - Area A Risk Calculations
Vapor Inhalation (Indoor Air), Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | CSF In (mg/kg-day) ⁻¹ | Cancer Risk | |
|--------------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|----------------------------------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | | RME | CT |
| Volatile Organic Compounds | | | | | | | | | | | |
| Tetrachloroethene | 4.0E-06 | 4.0E-06 | 5.9E-07 | 5.9E-07 | 5.4E-06 | 5.4E-06 | 2.1E-07 | 5.1E-08 | 2.6E-03 | 5.5E-10 | 1.3E-10 |
| TOTAL HAZARD INDEX | | | | | 5.E-06 | 5.E-06 | TOTAL CANCER RISK | | | 6.E-10 | 1.E-10 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-2 - Area A Risk Calculations
Fugitive Dust Inhalation, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF in m ³ /kg | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|---------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 1.32E+09 | 5.7E-09 | 1.8E-09 | 8.5E-10 | 2.7E-10 | -- | -- | 3.0E-10 | 2.3E-11 | 4.5E-09 | 3.5E-10 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 5.E-09 | 3.E-10 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-3 - Area A Risk Calculations
Soil Ingestion, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | |
| Benzo(a)anthracene | 1.1E-01 | 1.0E-01 | 1.8E-08 | 3.7E-09 | -- | -- | 2.6E-10 | 2.6E-11 | 1.9E-10 | 1.9E-11 |
| Benzo(a)pyrene | 1.2E-01 | 1.1E-01 | 2.0E-08 | 3.9E-09 | -- | -- | 2.9E-10 | 2.8E-11 | 2.1E-09 | 2.0E-10 |
| Benzo(b)fluoranthene | 1.0E-01 | 8.6E-02 | 1.7E-08 | 3.0E-09 | -- | -- | 2.4E-10 | 2.2E-11 | 1.8E-10 | 1.6E-11 |
| Dibenz(a,h)anthracene | 1.8E-02 | 1.8E-02 | 3.0E-09 | 6.3E-10 | -- | -- | 4.3E-11 | 4.5E-12 | 3.2E-10 | 3.3E-11 |
| Indeno(1,2,3-cd)pyrene | 8.1E-02 | 7.6E-02 | 1.4E-08 | 2.7E-09 | -- | -- | 2.0E-10 | 1.9E-11 | 1.4E-10 | 1.4E-11 |
| Metals | | | | | | | | | | |
| Arsenic | 7.4E+00 | 3.0E+00 | 1.2E-06 | 1.1E-07 | 4.2E-03 | 3.5E-04 | 1.8E-08 | 7.6E-10 | 2.7E-08 | 1.1E-09 |
| TOTAL HAZARD INDEX | | | | | 4.E-03 | 4.E-04 | TOTAL CANCER RISK | | 3.E-08 | 1.E-09 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-3 - Area A Risk Calculations
Dermal Contact with Soil, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | | |
| Benzo(a)anthracene | 0.13 | 1.1E-01 | 1.0E-01 | 2.0E-08 | 4.6E-09 | -- | -- | 2.9E-10 | 3.3E-11 | 2.1E-10 | 2.4E-11 |
| Benzo(a)pyrene | 0.13 | 1.2E-01 | 1.1E-01 | 2.2E-08 | 4.8E-09 | -- | -- | 3.2E-10 | 3.5E-11 | 2.3E-09 | 2.5E-10 |
| Benzo(b)fluoranthene | 0.13 | 1.0E-01 | 8.6E-02 | 1.9E-08 | 3.8E-09 | -- | -- | 2.7E-10 | 2.7E-11 | 2.0E-10 | 2.0E-11 |
| Dibenz(a,h)anthracene | 0.13 | 1.8E-02 | 1.8E-02 | 3.4E-09 | 7.9E-10 | -- | -- | 4.8E-11 | 5.7E-12 | 3.5E-10 | 4.1E-11 |
| Indeno(1,2,3-cd)pyrene | 0.13 | 8.1E-02 | 7.6E-02 | 1.5E-08 | 3.3E-09 | -- | -- | 2.2E-10 | 2.4E-11 | 1.6E-10 | 1.7E-11 |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 7.4E+00 | 3.0E+00 | 3.2E-07 | 3.1E-08 | 1.1E-03 | 1.0E-04 | 4.6E-09 | 2.2E-10 | 6.8E-09 | 3.3E-10 |
| TOTAL HAZARD INDEX | | | | | | 1.E-03 | 1.E-04 | TOTAL CANCER RISK | | 1.E-08 | 7.E-10 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-3 - Area A Risk Calculations
Vapor Inhalation (Outdoor Air), Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|-----------------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Volatile Organic Compounds | | | | | | | | | | |
| Tetrachloroethene | 6.2E-07 | 6.2E-07 | 3.3E-09 | 3.3E-09 | 3.0E-08 | 3.0E-08 | 4.7E-11 | 2.4E-11 | 9.5E-14 | 4.7E-14 |
| TOTAL HAZARD INDEX | | | | | 3.E-08 | 3.E-08 | TOTAL CANCER RISK | | 9.E-14 | 5.E-14 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-3 - Area A Risk Calculations
Fugitive Dust Inhalation, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF in m ³ /kg | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|---------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | | |
| Benzo(a)anthracene | 1.32E+09 | 8.3E-11 | 7.9E-11 | 4.4E-13 | 4.2E-13 | — | — | 6.3E-15 | 3.0E-15 | 2.0E-15 | 9.3E-16 |
| Benzo(a)pyrene | 1.32E+09 | 8.9E-11 | 8.3E-11 | 4.8E-13 | 4.5E-13 | — | — | 6.8E-15 | 3.2E-15 | 2.1E-14 | 9.9E-15 |
| Benzo(b)fluoranthene | 1.32E+09 | 7.7E-11 | 6.5E-11 | 4.1E-13 | 3.5E-13 | — | — | 5.9E-15 | 2.5E-15 | 1.8E-15 | 7.7E-16 |
| Dibenz(a,h)anthracene | 1.32E+09 | 1.4E-11 | 1.4E-11 | 7.3E-14 | 7.3E-14 | — | — | 1.0E-15 | 5.2E-16 | 3.2E-15 | 1.6E-15 |
| Indeno(1,2,3-cd)pyrene | 1.32E+09 | 6.1E-11 | 5.8E-11 | 3.3E-13 | 3.1E-13 | — | — | 4.7E-15 | 2.2E-15 | 1.5E-15 | 6.8E-16 |
| Metals | | | | | | | | | | | |
| Arsenic | 1.32E+09 | 5.6E-09 | 2.3E-09 | 3.0E-11 | 1.2E-11 | — | — | 4.3E-13 | 8.7E-14 | 6.4E-12 | 1.3E-12 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 6.E-12 | 1.E-12 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-4 - Area B Risk Calculations
Soil Ingestion, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | |
| Arsenic | 3.1E+00 | 3.0E+00 | 7.9E-05 | 2.2E-06 | 2.6E-01 | 7.3E-03 | 8.3E-06 | 2.0E-07 | 1.2E-05 | 3.0E-07 |
| TOTAL HAZARD INDEX | | | | | 3.E-01 | 7.E-03 | TOTAL CANCER RISK | | 1.E-05 | 3.E-07 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-4 - Area B Risk Calculations
Dermal Contact with Soil, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 3.1E+00 | 3.0E+00 | 3.0E-05 | 8.9E-07 | 9.9E-02 | 3.0E-03 | 2.8E-06 | 7.9E-08 | 4.2E-06 | 1.2E-07 |
| TOTAL HAZARD INDEX | | | | | | 1.E-01 | 3.E-03 | TOTAL CANCER RISK | | 4.E-06 | 1.E-07 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-4 - Area B Risk Calculations
Fugitive Dust Inhalation, Resident
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF in m ³ /kg | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|---------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 1.32E+09 | 2.3E-09 | 2.3E-09 | 1.2E-09 | 1.2E-09 | -- | -- | 5.9E-10 | 1.2E-10 | 8.9E-09 | 1.9E-09 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 9.E-09 | 2.E-09 |

P:\DATA\Jobs\Port of Portland\15230 Term 1 Support\Feasibility Study\Residual Risk Assessment\A-4

Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-5 - Area B Risk Calculations
Soil Ingestion, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|-----------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------|----------------------------|---------|-------------|---------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | |
| Arsenic | 3.1E+00 | 3.0E+00 | 3.0E-06 | 1.5E-06 | 1.0E-02 | 4.9E-03 | 1.1E-06 | 1.3E-07 | 1.6E-06 | 1.9E-07 |
| TOTAL HAZARD INDEX | | | | | 1.E-02 | 5.E-03 | TOTAL CANCER RISK | | 2.E-06 | 2.E-07 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-5 - Area B Risk Calculations
Dermal Contact with Soil, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 3.1E+00 | 3.0E+00 | 3.0E-07 | 2.3E-07 | 9.9E-04 | 7.5E-04 | 1.1E-07 | 1.9E-08 | 1.6E-07 | 2.9E-08 |
| TOTAL HAZARD INDEX | | | | | | 1.E-03 | 8.E-04 | TOTAL CANCER RISK | | 2.E-07 | 3.E-08 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-5 - Area B Risk Calculations
Fugitive Dust Inhalation, Commercial Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF in m ³ /kg | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|---------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| Metals | | | | | | | | | | | |
| Arsenic | 1.32E+09 | 2.3E-09 | 2.3E-09 | 3.5E-10 | 3.4E-10 | - | - | 1.2E-10 | 2.9E-11 | 1.9E-09 | 4.3E-10 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 2.E-09 | 4.E-10 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-6 - Area B Risk Calculations
Soil Ingestion, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | |
| Benzo(a)anthracene | 1.5E+00 | 4.6E-01 | 2.6E-07 | 1.6E-08 | - | - | 3.6E-09 | 1.2E-10 | 2.7E-09 | 8.5E-11 |
| Benzo(a)pyrene | 1.5E+00 | 4.8E-01 | 2.5E-07 | 1.7E-08 | - | - | 3.5E-09 | 1.2E-10 | 2.6E-08 | 8.8E-10 |
| Benzo(b)fluoranthene | 1.3E+00 | 4.0E-01 | 2.2E-07 | 1.4E-08 | - | - | 3.1E-09 | 1.0E-10 | 2.3E-09 | 7.3E-11 |
| Dibenz(a,h)anthracene | 2.5E-01 | 1.3E-01 | 4.2E-08 | 4.6E-09 | - | - | 6.0E-10 | 3.3E-11 | 4.4E-09 | 2.4E-10 |
| Indeno(1,2,3-cd)pyrene | 7.2E-01 | 2.8E-01 | 1.2E-07 | 9.9E-09 | - | - | 1.7E-09 | 7.1E-11 | 1.3E-09 | 5.2E-11 |
| Metals | | | | | | | | | | |
| Arsenic | 3.6E+00 | 2.9E+00 | 6.1E-07 | 1.0E-07 | 2.0E-03 | 3.4E-04 | 8.7E-09 | 7.3E-10 | 1.3E-08 | 1.1E-09 |
| TOTAL HAZARD INDEX | | | | | 2.E-03 | 3.E-04 | TOTAL CANCER RISK | | 5.E-08 | 2.E-09 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-6 - Area B Risk Calculations
Dermal Contact with Soil, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | ABS | Soil EPC in mg/kg | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|------|-------------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | | |
| Benzo(a)anthracene | 0.13 | 1.5E+00 | 4.6E-01 | 2.8E-07 | 2.0E-08 | -- | -- | 4.1E-09 | 1.4E-10 | 3.0E-09 | 1.1E-10 |
| Benzo(a)pyrene | 0.13 | 1.5E+00 | 4.8E-01 | 2.7E-07 | 2.1E-08 | -- | -- | 3.9E-09 | 1.5E-10 | 2.8E-08 | 1.1E-09 |
| Benzo(b)fluoranthene | 0.13 | 1.3E+00 | 4.0E-01 | 2.4E-07 | 1.7E-08 | -- | -- | 3.4E-09 | 1.2E-10 | 2.5E-09 | 9.1E-11 |
| Dibenz(a,h)anthracene | 0.13 | 2.5E-01 | 1.3E-01 | 4.6E-08 | 5.8E-09 | -- | -- | 6.6E-10 | 4.1E-11 | 4.8E-09 | 3.0E-10 |
| Indeno(1,2,3-cd)pyrene | 0.13 | 7.2E-01 | 2.8E-01 | 1.3E-07 | 1.2E-08 | -- | -- | 1.9E-09 | 8.9E-11 | 1.4E-09 | 6.5E-11 |
| Metals | | | | | | | | | | | |
| Arsenic | 0.03 | 3.6E+00 | 2.9E+00 | 1.6E-07 | 2.9E-08 | 5.2E-04 | 9.8E-05 | 2.2E-09 | 2.1E-10 | 3.3E-09 | 3.2E-10 |
| TOTAL HAZARD INDEX | | | | | | 5.E-04 | 1.E-04 | TOTAL CANCER RISK | | 4.E-08 | 2.E-09 |

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Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

Table A-6. - Area B Risk Calculations
Fugitive Dust Inhalation, Excavation Worker
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| Compounds of Potential Concern | PEF in m ³ /kg | Air EPC in mg/3 | | Hazard Intake in mg/kg-day | | Hazard Quotient | | Cancer Intake in mg/kg-day | | Cancer Risk | |
|--------------------------------|---------------------------|-----------------|---------|----------------------------|---------|-----------------|---------------|----------------------------|---------|---------------|---------------|
| | | RME | CT | RME | CT | RME | CT | RME | CT | RME | CT |
| PAHs | | | | | | | | | | | |
| Benzo(a)anthracene | 1.3E+09 | 1.1E-09 | 3.5E-10 | 6.1E-12 | 1.9E-12 | -- | -- | 8.7E-14 | 1.3E-14 | 2.7E-14 | 4.1E-15 |
| Benzo(a)pyrene | 1.3E+09 | 1.1E-09 | 3.6E-10 | 5.9E-12 | 1.9E-12 | -- | -- | 8.4E-14 | 1.4E-14 | 2.6E-13 | 4.3E-14 |
| Benzo(b)fluoranthene | 1.3E+09 | 9.7E-10 | 3.0E-10 | 5.2E-12 | 1.6E-12 | -- | -- | 7.4E-14 | 1.2E-14 | 2.3E-14 | 3.6E-15 |
| Dibenz(a,h)anthracene | 1.3E+09 | 1.9E-10 | 1.0E-10 | 1.0E-12 | 5.4E-13 | -- | -- | 1.4E-14 | 3.8E-15 | 4.4E-14 | 1.2E-14 |
| Indeno(1,2,3-cd)pyrene | 1.3E+09 | 5.4E-10 | 2.1E-10 | 2.9E-12 | 1.1E-12 | -- | -- | 4.2E-14 | 8.2E-15 | 1.3E-14 | 2.5E-15 |
| Metals | | | | | | | | | | | |
| Arsenic | 1.3E+09 | 2.7E-09 | 2.2E-09 | 1.5E-11 | 1.2E-11 | -- | -- | 2.1E-13 | 8.4E-14 | 3.1E-12 | 1.3E-12 |
| TOTAL HAZARD INDEX | | | | | | 0.E+00 | 0.E+00 | TOTAL CANCER RISK | | 3.E-12 | 1.E-12 |

Notes:

RME = Reasonable Maximum Exposure.

CT = Central Tendency.

EPC = Exposure Point Concentration.

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**Table A-7 - Revised Exposure Point Concentrations: Soil and Groundwater
Marine Terminal 1 South Feasibility Study
Portland, Oregon**

| Analyte | max | Distribution | 90 % UCL | Arithmetic Mean | EPC | |
|--|--------|-----------------|----------|-----------------|---------|---------|
| | | | | | RME | CT |
| AREA A: SURFACE SOIL (0 to 3 feet bgs) | | | | | | |
| Metals in mg/kg | | | | | | |
| Arsenic | 7.53 | Lognormal | 1.4E+01 | 2.4E+00 | 7.5E+00 | 2.4E+00 |
| Lead | 28.1 | Lognormal | 3.7E+02 | 9.5E+00 | 2.8E+01 | 9.5E+00 |
| TPH in mg/kg | | | | | | |
| Diesel Range | 45.2 | Assm. Lognormal | 2.7E+01 | 2.0E+01 | 2.7E+01 | 2.0E+01 |
| Oil-Range | 191 | Assm. Lognormal | 6.1E+01 | 4.5E+01 | 6.1E+01 | 4.5E+01 |
| AREA A: TOTAL SOIL (0 to 15 feet bgs) | | | | | | |
| PAHs in mg/kg | | | | | | |
| Benzo(a)anthracene | 1.76 | Weak Lognormal | 1.1E-01 | 1.0E-01 | 1.1E-01 | 1.0E-01 |
| Benzo(a)pyrene | 1.86 | Weak Lognormal | 1.2E-01 | 1.1E-01 | 1.2E-01 | 1.1E-01 |
| Benzo(b)fluoranthene | 1.09 | Weak Lognormal | 1.0E-01 | 8.6E-02 | 1.0E-01 | 8.6E-02 |
| Dibenz(a,h)anthracene | 0.0176 | Maximum | 1.8E-02 | 3.8E-02 | 1.8E-02 | 1.8E-02 |
| Indeno(1,2,3-cd)pyrene | 1.09 | Weak Lognormal | 8.1E-02 | 7.6E-02 | 8.1E-02 | 7.6E-02 |
| Metals in mg/kg | | | | | | |
| Arsenic | 11.2 | Lognormal | 7.4E+00 | 3.0E+00 | 7.4E+00 | 3.0E+00 |
| Lead | 28.1 | Lognormal | 5.4E+01 | 9.3E+00 | 2.8E+01 | 9.3E+00 |
| TPH in mg/kg | | | | | | |
| Diesel Range | 1170 | Assm. Lognormal | 6.1E+01 | 7.9E+01 | 7.9E+01 | 7.9E+01 |
| Oil-Range | 1760 | Assm. Lognormal | 1.4E+02 | 1.7E+02 | 1.7E+02 | 1.7E+02 |
| AREA B: SURFACE SOIL (0 to 3 feet bgs) | | | | | | |
| Metals in mg/kg | | | | | | |
| Arsenic | 3.1 | Maximum | 3.1E+00 | 3.0E+00 | 3.1E+00 | 3.0E+00 |
| TPH in mg/kg | | | | | | |
| Oil-Range | 6030 | Maximum | 6.0E+03 | 1.6E+03 | 6.0E+03 | 1.6E+03 |
| AREA B: TOTAL SOIL (0 to 15 feet bgs) | | | | | | |
| PAHs in mg/kg | | | | | | |
| Benzo(a)anthracene | 1.51 | Lognormal | 5.2E+00 | 4.6E-01 | 1.5E+00 | 4.6E-01 |
| Benzo(a)pyrene | 1.45 | Lognormal | 5.5E+00 | 4.8E-01 | 1.5E+00 | 4.8E-01 |
| Benzo(b)fluoranthene | 1.28 | Lognormal | 3.8E+00 | 4.0E-01 | 1.3E+00 | 4.0E-01 |
| Dibenz(a,h)anthracene | 0.247 | Lognormal | 4.2E-01 | 1.3E-01 | 2.5E-01 | 1.3E-01 |
| Indeno(1,2,3-cd)pyrene | 0.718 | Lognormal | 1.7E+00 | 2.8E-01 | 7.2E-01 | 2.8E-01 |
| Metals in mg/kg | | | | | | |
| Arsenic | 3.6 | Maximum | 3.6E+00 | 2.9E+00 | 3.6E+00 | 2.9E+00 |
| TPH in mg/kg | | | | | | |
| Diesel Range | 3440 | Assm. Lognormal | 7.4E+02 | 3.1E+02 | 7.4E+02 | 3.1E+02 |
| Oil-Range | 20700 | Assm. Lognormal | 9.9E+03 | 1.9E+03 | 9.9E+03 | 1.9E+03 |
| AREA C: SURFACE SOIL (0 to 3 feet bgs) | | | | | | |
| Metals in mg/kg | | | | | | |
| Arsenic | 2.9 | NA | 2.9E+00 | 2.9E+00 | 2.9E+00 | 2.9E+00 |
| AREA C: TOTAL SOIL (0 to 15 feet bgs) | | | | | | |
| Metals in mg/kg | | | | | | |
| Arsenic | 11.8 | NA | 1.2E+01 | 5.8E+00 | 1.2E+01 | 5.8E+00 |

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Notes:

Acronyms and Abbreviations:

EPC = Exposure point concentration.

PAHs = Polynuclear aromatic hydrocarbons.

RME = Reasonable maximum exposure.

CT = Central Tendency.

SQL = Standard quantification limit.

NA = Not applicable.

Table A-8 - Revised Risk and Hazard Summary: By Exposure Pathway
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| SubArea | Exposure Scenario | RME Cancer Risk | | | | | RME Hazard Index | | | | |
|---------|-------------------|-----------------|--------|-------------------------|--------------------|--------|------------------|--------|-------------------------|--------------------|--------|
| | | Ingestion | Dermal | Inhalation of Volatiles | Inhalation of Dust | TOTAL | Ingestion | Dermal | Inhalation of Volatiles | Inhalation of Dust | TOTAL |
| Area A | Resident | 3.E-05 | 1.E-05 | 4.E-09 | 1.E-08 | 4.E-05 | 6.E-01 | 2.E-01 | 8.E-05 | 0.E+00 | 8.E-01 |
| | Commercial Worker | 4.E-06 | 4.E-07 | 6.E-10 | 5.E-09 | 4.E-06 | 2.E-02 | 2.E-03 | 5.E-06 | 0.E+00 | 2.E-02 |
| | Excavation Worker | 3.E-08 | 1.E-08 | 9.E-14 | 6.E-12 | 4.E-08 | 4.E-03 | 1.E-03 | 3.E-08 | 0.E+00 | 5.E-03 |
| Area B | Resident | 1.E-05 | 4.E-06 | NA | 9.E-09 | 1.E-05 | 3.E-01 | 1.E-01 | NA | 0.E+00 | 4.E-01 |
| | Commercial Worker | 2.E-06 | 2.E-07 | NA | 2.E-09 | 2.E-06 | 1.E-02 | 1.E-03 | NA | 0.E+00 | 1.E-02 |
| | Excavation Worker | 5.E-08 | 4.E-08 | NA | 3.E-12 | 9.E-08 | 2.E-03 | 5.E-04 | NA | 0.E+00 | 3.E-03 |
| Area C | Resident | 1.E-05 | 4.E-06 | NA | 8.E-09 | 2.E-05 | 2.E-01 | 9.E-02 | NA | 0.E+00 | 3.E-01 |
| | Commercial Worker | 2.E-06 | 1.E-07 | NA | 2.E-09 | 2.E-06 | 9.E-03 | 9.E-04 | NA | 0.E+00 | 1.E-02 |
| | Excavation Worker | 4.E-08 | 1.E-08 | NA | 1.E-11 | 5.E-08 | 7.E-03 | 2.E-03 | NA | 0.E+00 | 9.E-03 |

| SubArea | Exposure Scenario | CT Cancer Risk | | | | | CT Hazard Index | | | | |
|---------|-------------------|----------------|--------|-------------------------|--------------------|--------|-----------------|--------|-------------------------|--------------------|--------|
| | | Ingestion | Dermal | Inhalation of Volatiles | Inhalation of Dust | TOTAL | Ingestion | Dermal | Inhalation of Volatiles | Inhalation of Dust | TOTAL |
| Area A | Resident | 2.E-07 | 9.E-08 | 2.E-09 | 1.E-09 | 3.E-07 | 6.E-03 | 2.E-03 | 8.E-05 | 0.E+00 | 8.E-03 |
| | Commercial Worker | 2.E-07 | 2.E-08 | 1.E-10 | 3.E-10 | 2.E-07 | 4.E-03 | 6.E-04 | 5.E-06 | 0.E+00 | 5.E-03 |
| | Excavation Worker | 1.E-09 | 7.E-10 | 5.E-14 | 1.E-12 | 2.E-09 | 4.E-04 | 1.E-04 | 3.E-08 | 0.E+00 | 5.E-04 |
| Area B | Resident | 3.E-07 | 1.E-07 | NA | 2.E-09 | 4.E-07 | 7.E-03 | 3.E-03 | NA | 0.E+00 | 1.E-02 |
| | Commercial Worker | 2.E-07 | 3.E-08 | NA | 4.E-10 | 2.E-07 | 5.E-03 | 8.E-04 | NA | 0.E+00 | 6.E-03 |
| | Excavation Worker | 2.E-09 | 2.E-09 | NA | 1.E-12 | 4.E-09 | 3.E-04 | 1.E-04 | NA | 0.E+00 | 4.E-04 |
| Area C | Resident | 3.E-07 | 1.E-07 | NA | 2.E-09 | 4.E-07 | 7.E-03 | 3.E-03 | NA | 0.E+00 | 1.E-02 |
| | Commercial Worker | 2.E-07 | 3.E-08 | NA | 4.E-10 | 2.E-07 | 5.E-03 | 7.E-04 | NA | 0.E+00 | 6.E-03 |
| | Excavation Worker | 2.E-09 | 6.E-10 | NA | 3.E-12 | 3.E-09 | 7.E-04 | 2.E-04 | NA | 0.E+00 | 9.E-04 |

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Note:

1. Shaded boxes indicate exposure scenarios that exceed DEQ's acceptable risk targets.

Table A-9 - Revised RME Risk Summary: By COPC
Marine Terminal 1 South Feasibility Study
Portland, Oregon

| SubArea | Exposure Scenario | COPC | RME Cancer Risk | | | | TOTAL |
|---------|-------------------|-------------------|-----------------|---------------|----------------------------|-----------------------|---------------|
| | | | Ingestion | Dermal | Inhalation of Volatiles | Inhalation of Dust | |
| Area A | Resident | Arsenic | 3.E-05 | 1.E-05 | na | 1.E-08 | 4.E-05 |
| | | Tetrachloroethene | na | na | 4.E-09 | na | 4.E-09 |
| | | TOTAL | 3.E-05 | 1.E-05 | 4.E-09 | 1.E-08 | 4.E-05 |
| | Commercial Worker | Arsenic | 4.E-06 | 4.E-07 | na | 5.E-09 | 4.E-06 |
| | | Tetrachloroethene | na | na | 6.E-10 | na | 6.E-10 |
| | | TOTAL | 4.E-06 | 4.E-07 | 6.E-10 | 5.E-09 | 4.E-06 |
| Area B | Resident | Arsenic | 1.E-05 | 4.E-06 | na | 9.E-09 | 2.E-05 |
| | | TOTAL | 1.E-05 | 4.E-06 | na | 9.E-09 | 2.E-05 |
| | Commercial Worker | Arsenic | 2.E-06 | 2.E-07 | na | 2.E-09 | 2.E-06 |
| | | TOTAL | 2.E-06 | 2.E-07 | na | 2.E-09 | 2.E-06 |
| Area C | Resident | Arsenic | 1.E-05 | 4.E-06 | na | 8.E-09 | 2.E-05 |
| | Commercial Worker | Arsenic | 2.E-06 | 2.E-07 | na | 2.E-09 | 2.E-06 |

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Note:

1. Shaded boxes indicate COPC that exceeds DEQ acceptable risk target.